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NCEL Techdata Sheet

Controlling Electromagnetic Interference From Wind Energy Conversion Systems

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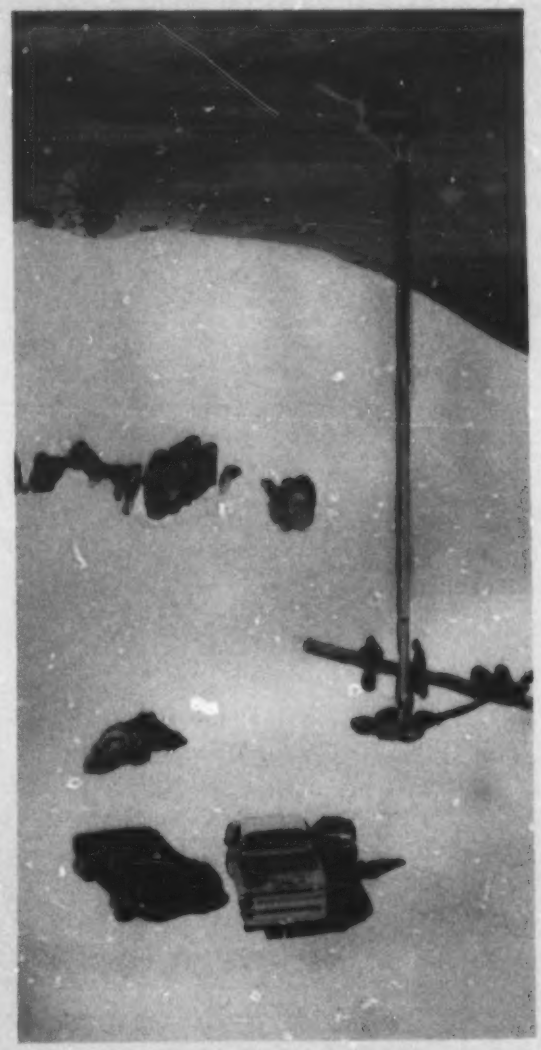
This Techdata Sheet describes how wind energy conversion systems (WECS) can induce electromagnetic interference (EMI) and provides guidance to control it. The information presented in this TDS can be used by Public Works Officers and utility groups involved with applications of wind power at Navy bases.

TYPES OF WECS INDUCED EMI

Several major WECS components, such as rotor blades, hub assembly, transmission, generators, field and yaw sliprings, power cables, and power conditioning system, are potential sources of EMI. The three principal types of EMI that can be produced by WECS are:

1. Conducted – electromagnetic emissions propagated along power leads and cables.
2. Radiated – electromagnetic emissions propagated into space from the generator, power leads and cables, and power conditioning equipment.
3. Reflected and reradiated – a form of reflected emission into space from WECS components, such as rotor, nacelle and tower, of signals present in the WECS vicinity.



Radiated and conducted EMI can be readily measured. There are companies which specialize in these type of measurements. The field measurements for the 10- and 40-kW WECS are shown in Table 1. The physical characteristics of each are shown in Table 2. The results from evaluating the operation of both the 10- and 40-kW WECS at two different sites revealed some increase in

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Table 1. Results of Conducted and Radiated EMI Tests on 10- and 40-kW WECS

Type of EMI	10 kW	40 kW
Conducted (nonoperating)	• Ambient noise was extremely low except at ground level.	• Ambient noise was extremely low on all lines.
Conducted (operating)	• Major emissions above 10 kHz to 1 MHz. • Both broad and narrow band. • Emissions above 1 MHz were quite low.	• Major emissions from 0 to 10 MHz. • Emissions above 10 MHz were very low. • Low and similar emissions on all lines. • Both broad and narrow band.
Radiated	• Measured 100 ft from WECS. • Measured at 3 quadrants: 0, 120, and 240 deg. • Both narrow and broad band. • Low-level emissions below 10 MHz. • No emissions above 10 MHz to 1.1 GHz.	• Measured 100 ft from WECS. • Ambient noise was low. • Emissions were observed below 1 MHz. • Very low emissions were observed from 1 MHz to 1.1 GHz.

Table 2. Physical Characteristics of 10- and 40-kW WECS

Item	10 kW	40 kW
Rotor diameter, ft	23	44
Blade material	Fiberglass	Laminated wood
Tower height, ft	60 Steel truss	80 Steel truss
Electrical generator	Permanent magnet alternator	Induction
Power conditioning	Line-commutated inverter	None

the level of EMI over the ambient noise for the frequency shown in Table 1, but it was not sufficient to warrant any concern. The levels of radiated noise for the 10-kW WECS were more than for the 40-kW WECS. This was primarily attributed to the difference in the configuration of the powerlines from the generator for the two WECS. The 10-kW WECS powerlines were overhead, while the 40-kW WECS powerlines were underground.

Reflected or scattered EMI is extremely difficult to measure in the field. There are some empirical results which can be useful for minimizing WECS-generated scattered emissions. Scattered EMI is generated by the rotating blades of a horizontal WECS and the WECS support tower. In the vicinity of WECS, the signals scattered by the blades combine with the primary signal to create a time-varying signal in synchronization with the rotation rate of the blades. This scattering causes amplitude modulations of the total signal.

Both forward and backward scattering of a signal can occur, as illustrated in Figure 1.

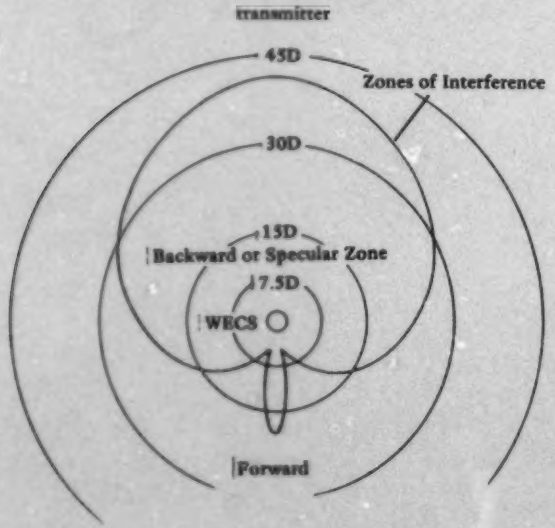

Figure 1. Interference Radiation Patterns (WECS rotor diameter is D).

The forward interference region directed away from the transmitter results in forward scattering off the blades.

The backward or specular zone is roughly a cardioid centered with the maximum pointing toward the transmitter. In Figure 1, the maximum interference distances for the backward and forward interference zones are established through field measurements. Determination is laborious and will not be presented here. Generally the values of maximum interference zones for WECS are dependent upon the rotor diameter (i.e., scattering area), acceptable interference level, frequency of the transmission, and the amplitudes of the scattered field and the ambient field at the receiver. The amplitudes of these fields are dependent upon the distance of the WECS from the transmitter and receiver. Receivers within these radiation patterns will receive EMI. However, a careful siting of a prospective WECS installation can minimize effects of scattered EMI.

GUIDANCE FOR CONTROL

Application of wind power at remote sites on islands and isolated mountain tops has proved to be cost effective. However, most of these sites house communications equipment, which is extremely sensitive to the ambient electromagnetic environment. The location of wind energy conversion systems at such sites could have an adverse effect on the ambient electromagnetic environment and thus on the performance of the communications gear. It is known that sizing and placement of WECS are critical to ensure electromagnetic compatibility (EMC) and to minimize electromagnetic interference produced by WECS of all sizes. There is considerable theoretical documentation and some field data that show how placement of WECS can minimize or eliminate EMI.

Placing WECS in close proximity to communication and other sensitive gear aboard Navy installations will invariably require use of appropriate shielding, bonding, grounding, and filtering to achieve acceptable EMI levels to meet operational requirements. Shielding in the form of metallic grids encased in the nacelle may be required to suppress radiated EMI from the drivetrain, electrical generator, controls, and sliprings. All the power carrying conductors must be properly shielded. Use of adequate filters may be necessary to suppress conducted harmonies from the power conditioning system into the base distribution network.

NAVELEX 0101,108, Naval Shore Electronic Criteria, May 1973, provides guidance for location of structures to prevent EMI: metallic and nonmetallic structures must not subtend a vertical angle greater than 3 degrees above the horizon when measured at the antenna base.

Figure 2 depicts the range of the electromagnetic spectrum. Annotated are the frequency bands that will receive EMI if placed in the vicinity of a WECS. Historical data indicated that EMI occurs primarily in the Very High Frequency (VHF) range, whereas no EMI has been experienced in the Ultra High Frequency (UHF) band. The EMI generated by the large WECS using 100-foot-plus rotors will cause television video reception problems, whereas the small WECS with rotor diameters of 40 feet or less will cause no distortion.

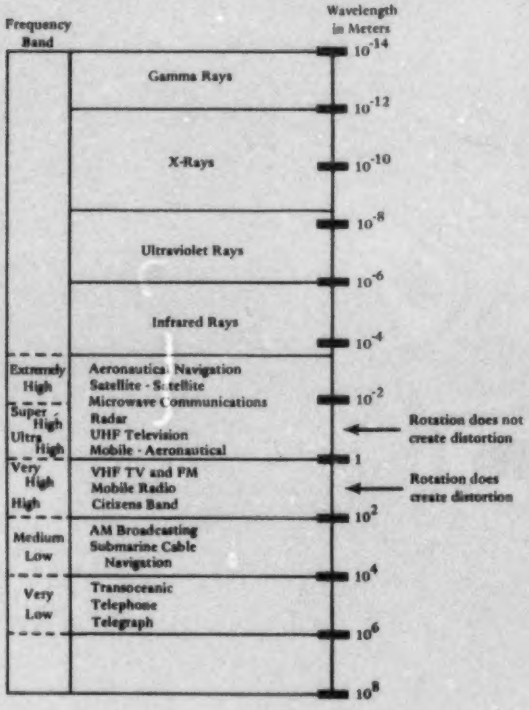

Figure 2. Electromagnetic Spectrum.

SUMMARY

- Several components of WECS are potential EMI sources.
- WECS can produce conducted, radiated, and reflected or reradiated interference. A well-designed WECS with a rotor diameter of 40 feet or less will not generate EMI levels high enough to cause problems.
- Potential problems created by WECS radiated, reflected, and conducted EMI can be eliminated by application of proper suppression techniques involving use of metallic grids and shields to house the transmission, electric generator, and controls and use of filters in power lines.
- Depending upon the WECS size, reflected or scattered signals from its components can be a source of interference. Therefore, careful presiting investigations are necessary to eliminate these effects.
- When planning a WECS installation at a sensitive electronic site, contact NCEL for guidance on possible EMI impacts.

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